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THE GENESIS OF LAKE AGASSIZ.¹

IN a paper read before the Geological Society of America on December 28, last, entitled *The Relation between Ice-Lobes South from the Wisconsin Driftless Area*, Mr. Frank Leverett² appears to have made some very interesting records of the relative ages of the sheets of drift in Illinois and vicinity. As these are directly in line with the observations made by me during the past few years in Manitoba, and throughout the country northward lying west of Hudson Bay, a few notes on the conclusions to which these observations tend may be of interest in advance of the publication of my detailed reports and maps by the Geological Survey of Canada.

In a short paper published in the *Geological Magazine* for September 1894, based on the explorations of 1892 and 1893, the writer outlined the existence, during the Glacial Period, of a great glacial center or gathering ground lying comparatively close to the west coast of Hudson Bay, from which the ice radiated in all directions; eastward into the basin of Hudson Bay, which was probably an open body of water then as it is now, and furnished the moisture for the immense precipitation of snow a short distance to the west of it; southward towards Manitoba and the Great Plains; westward towards the Athabasca-Mackenzie Valley and the Rocky Mountains; northwestward and northward³ toward the Arctic Ocean.

A second expedition by the writer through the same or adjoining country in 1894 served to corroborate and strengthen the conclusions reached in the preceding years. At or near the

¹ Published by permission of the Director of the Geological Survey of Canada.

² Abstract in *American Geologist*, February 1896, p. 102.

³ Notes to accompany a Geological Map of the Northern portion of the Dominion of Canada, by GEORGE M. DAWSON, Ann. Rep. Geol. Sur. Can., Vol. II, 1886, Part R. p. 57.

center of glaciation the striæ were found to be very indefinite, and to have changed in direction as the center slightly shifted its position, but no evidence of any other general glaciation could be found, or that the ice had left the country uncovered from the beginning to the close of the Glacial Epoch.

In the *Geographical Journal* for November 1895, p. 439, I have used the name Keewatin glacier for this continental ice-sheet, as its center lay in the northern portions of the District of Keewatin, and I shall continue to use that name, with the understanding that if it prove to be the same as the ice-sheet of the Kansan or Iowan period it will give place to one of these prior names unless indeed both of the latter should be found to represent re-advances of the same glacier, in which case the name "Keewatin" might conveniently be retained. At the same time I would suggest that Dr. Dawson's name "Laurentide Glacier" be restricted to that great *mer de glace* centering over the country north of the St. Lawrence River and the heights of Labrador.

A portion of the former glacier, advancing southward or southwestward, came in contact with the high escarpment of Cretaceous shales in western Manitoba, and by it was diverted more to the eastward, taking the trend of the great valley of Lake Winnipeg and the Red River. In this direction it appears to have advanced far into Minnesota, Dakota, and Iowa. The Palæozoic limestones of western Manitoba are beautifully scored by its markings, and its grooves and striæ were detected in many places as far east as the east side of Lake Winnipeg. East of Lake Winnipeg the exposed surfaces of the Archæan rocks were carefully searched for this set of markings, but none could be detected. It therefore seems probable that the eastern edge of this lobe or portion of the Keewatin glacier did not extend very far east of the present eastern shore of Lake Winnipeg, and it is also probable that throughout its advance there was a free drainage eastward, probably into Hudson Bay.

Traces of the existence of the streams that flowed eastward from the face or side of this glacier were found in several places in the form of deep pot-holes excavated in the summits or on

the eastern slopes of knolls of granite and gneiss, where they could not have been formed by the present streams or by others, like them, flowing westward. At one place, on the south side of Berens River, several of these pot-holes occur on the east side of a granite knoll, one of them, at least, being ten feet in depth, and about thirty inches in diameter from top to bottom. On the same side of the knoll, facing up the present stream, was a well-marked water-worn groove, leading down to a shallow pot-hole at the foot of the hill. The ten-foot hole was cleaned out and was found to contain a great number of well-rounded pebbles, all of Archæan rocks, some similar to the rocks of the surrounding country and others that had evidently been transported from a distance. Both this and the other rocky hills where the pot-holes were seen have been eroded and scored by the later glacier from the east, the outer sides of some of the holes having been cut away, leaving rounded niches in the faces of the smooth hillsides.

After occupying the basin of Lake Winnipeg and the Red River Valley for an uncertain but doubtless long period of time, the Keewatin glacier began gradually to retire. As it retired a portion of the Laurentide glacier, which in the meantime had been accumulating in the country farther east, perhaps in the high land of the Labrador peninsula, gradually advanced. The Keewatin glacier seems to have retired northward well into Manitoba, and possibly even beyond the northern limit of that province, before it was joined by the eastern glacier. When they united the water was ponded between the fronts of the two glaciers to the north and east, and the high land to the south and west. Thus Lake Agassiz had its beginning. Its waters rapidly rose until they overflowed southward into the valley of the Mississippi and then gradually declined as the river Warren deepened its channel.

After the union of the two glaciers the Keewatin glacier may have remained stationary for a considerable period, during which time the strong ridge extending from Long Point westward between Cedar and Winnipegosis lakes and beyond, apparently

crossing the Saskatchewan River at the Pas, was formed in the bed of this lake.

Meanwhile the eastern glacier was advancing towards its extreme western limit near the west shore of Lake Winnipeg, for it never crossed the belt of land intervening between that lake and lakes Manitoba and Winnipegosis. Before it reached the mouth of the Saskatchewan River, on the west side of this lake, the Keewatin glacier had already retired a considerable distance farther north, a sufficient time having elapsed to permit of the deposition in the bed of the lake of at least twelve feet of thinly and evenly stratified sands and clays over till of the earlier glacier, before they were covered by the till of the later glacier. The section of these two tills, with the intermediate stratified deposits, is well exposed on the bank of the Saskatchewan River near its mouth, and has been described by the writer in his "Report on Northwestern Manitoba."¹

The later history of Lake Agassiz has not yet been definitely determined, but it would seem reasonably certain that the Keewatin glacier continued to retire northward until it separated from the eastern glacier. Then the water would drain freely around the northern end of the latter glacier to Hudson Bay. The northeastern drainage has been shown by Mr. Upham² to have begun at the level of the Blanchard Beaches, the highest of which, along the line of the Manitoba and Northwestern Railway, is stated to be at an elevation of 994 feet above the sea or 284 above the present level of Lake Winnipeg. The eastern glacier seems to have now begun to retire, and its front had retired to a short distance east of the east shore of Lake Winnipeg when the Burnside and Gladstone Beaches were formed at elevations of from 150 to 170 feet above the present lake. Stratified Lake Agassiz sands and clays were deposited in considerable thickness on this side of the lake up to the above level, apparently near the front of the glacier. That the eastern glacier

¹ Ann. Rep. Geol. Sur. Can., Vol. V, 1890-1, Ottawa 1893, Part E, p. 146.

² Report of Exploration of the Glacial Lake Agassiz in Manitoba, by WARREN UPHAM, Ann. Rep. Geol. Sur. Can., Vol. IV, 1888-9, Part E.

had not retired further east during the time when Lake Agassiz stood at a higher level is shown by the absence of stratified lacustral deposits above the 150-170-foot line, in many places only a very few miles from Lake Winnipeg, an absence peculiarly noticeable as these deposits occur in such abundance below that line.

It is thus seen that the Keewatin glacier, which centered west of the northern part of Hudson Bay, had extended southward to its furthest limit, and had then retired many hundreds of miles, probably more than half way to its gathering ground, before the Laurentide glacier had reached its greatest extension.

Dr. Dawson¹ has also shown that the Cordilleran glacier reached its greatest extent and retired before boulder-clay that generally underlies the western plains was deposited. This boulder-clay I take to be the true till or ground moraine of the Keewatin glacier, when this glacier had reached its greatest extent in a southwesterly direction.

The evidence at present at hand would therefore seem to strengthen the view that in the northern part of this continent during the glacial period there were three great centers of snow and ice accumulation, one, the Cordilleran in the mountains of British Columbia, a second, the Keewatin, on the comparatively low land northwest of Hudson Bay, a third, the Laurentide, in the Labrador Peninsula.

Beginning at the west, and going eastward, these three great glaciers would seem to have reached their widest extent and retired in succession. Still further east, across Davis Straits, a fourth great glacier, probably similar in character to those that have disappeared from the American continent, covers Greenland at the present time.

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¹Glacial Deposits of Southwestern Alberta, in the vicinity of the Rocky Mountains, by GEORGE M. DAWSON, Bull. Geol. Sur. Am., Vol. VII, pp. 31-66. Nov. 1895.